气候变化与黄河流域管理
Climate Change and Yellow River Basin Management

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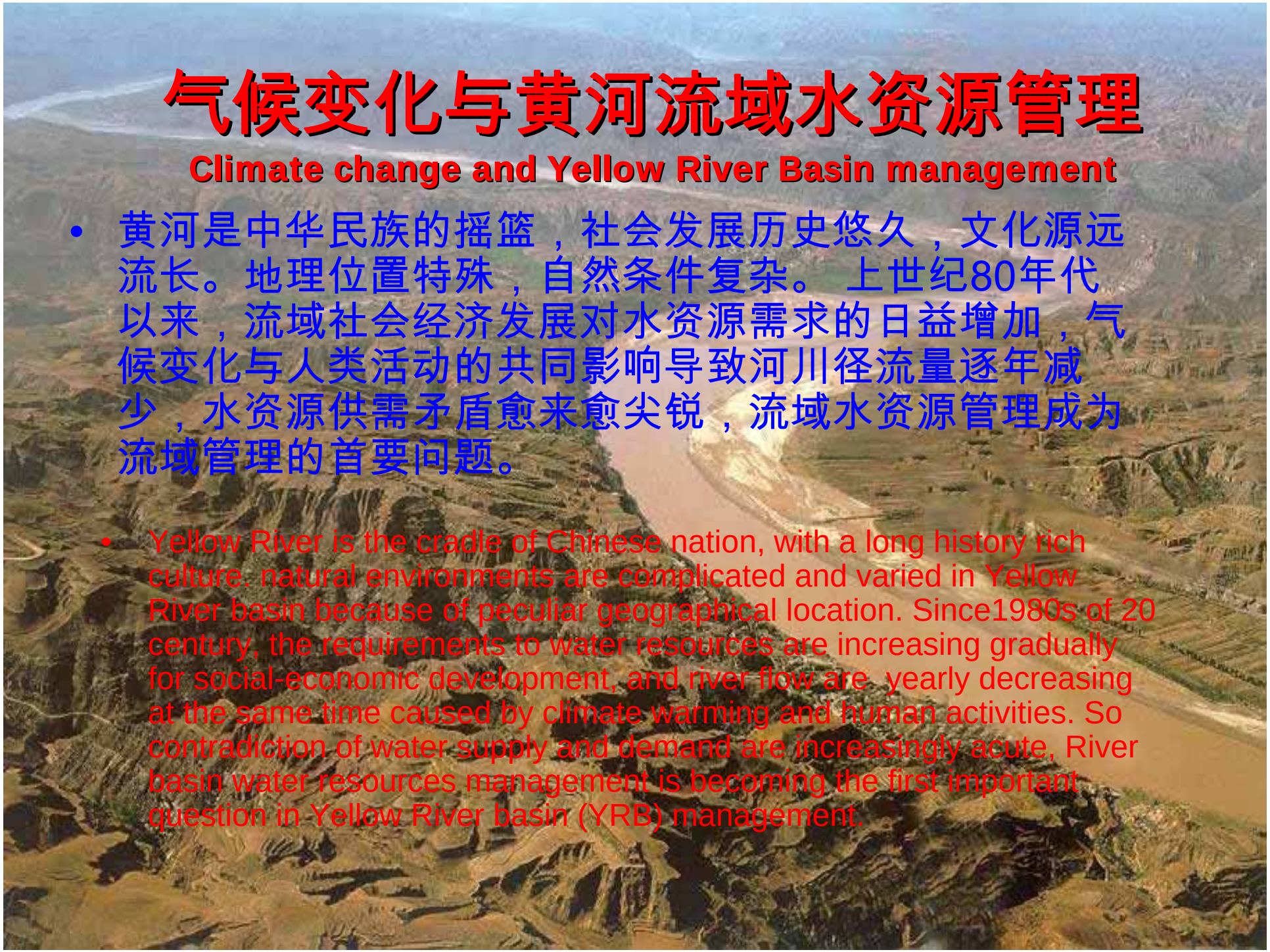

气候变化与黄河流域水资源管理

Climate change and Yellow River Basin management

- 黄河是中华民族的摇篮，社会发展历史悠久，文化源远流长。地理位置特殊，自然条件复杂。 上世纪80年代以来，流域社会经济发展对水资源需求的日益增加，气候变化与人类活动的共同影响导致河川径流量逐年减少，水资源供需矛盾愈来愈尖锐，流域水资源管理成为流域管理的首要问题。

- Yellow River is the cradle of Chinese nation, with a long history rich culture. natural environments are complicated and varied in Yellow River basin because of peculiar geographical location. Since1980s of 20 century, the requirements to water resources are increasing gradually for social-economic development, and river flow are yearly decreasing at the same time caused by climate warming and human activities. So contradiction of water supply and demand are increasingly acute, River basin water resources management is becoming the first important question in Yellow River basin (YRB) management.

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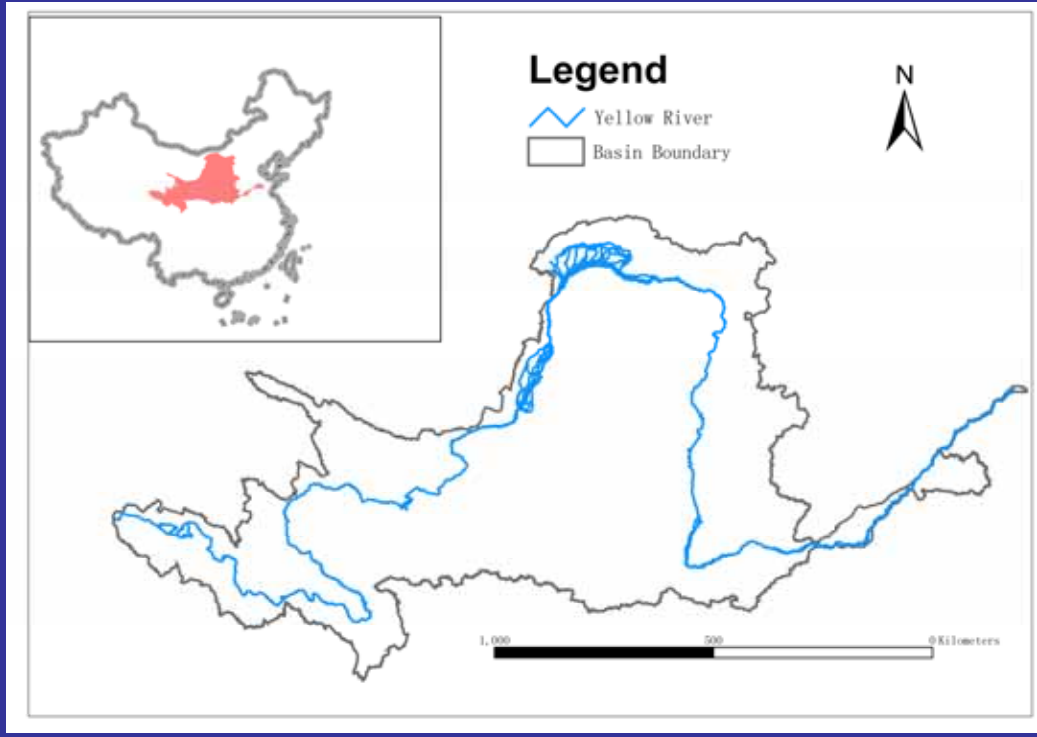
1. 黄河流域概况
General situation of YRB

- Location



Location of the Yellow River Basin in China

黄河流域水资源基本特点
Feature of water resources

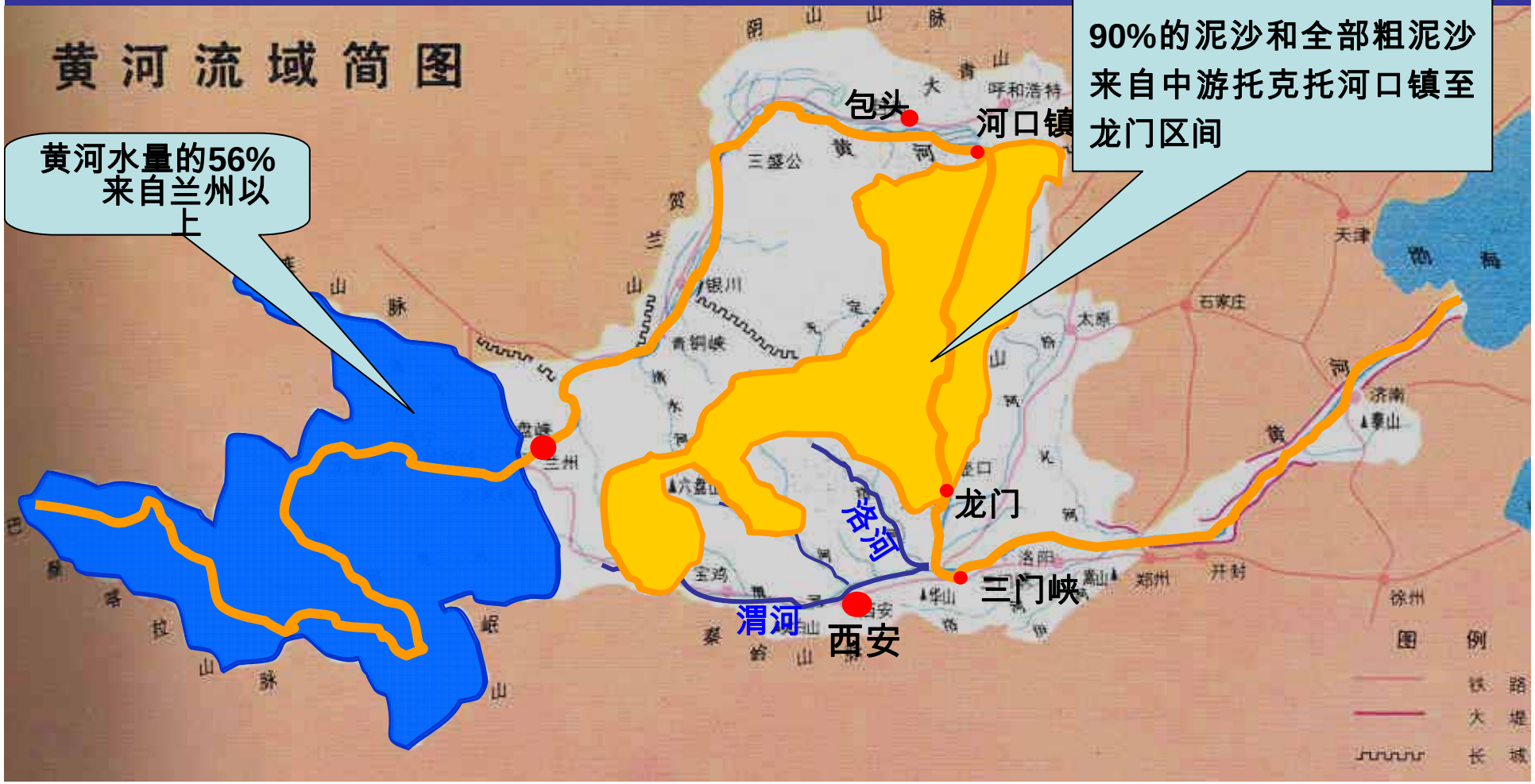
- 天然径流量为535亿m3，多年平均输沙量12.47亿吨，是世界上输沙量最大的河流；兰州以上水量占黄河的62%，是黄河主要产流区；河口镇至龙门区间水量占黄河的9%，沙量约54%，是黄河主要产沙区；黄河干支流来沙系数大、含沙量高，河道泥沙淤积严重。

  Average annual natural runoff: 53.5 billions m3, Sediment: 1.25 billions Ton (first in the world)

  Source region: 15% area, 1/3 water yield of whole YRB

  Middle region: 90% sediment yield

水少沙多、水沙异源、水沙关系不协调是黄河水资源的突出特点“*Less water with more sediment, different original area of sediment and water, unbalanced sediment discharge relationship*” is the remarkable characters of Yellow River water resources.



2. 黄河流域气候变化特点

Character of climate change in YRB

气温 和降水变化
Temperature and precipitation

- **统计数据表明，20世纪80年代以来，黄河流域气温明显升高，降水量有所减少。**
  Results of observed data analysis show that precipitation has decreased while temperature increased obviously in Yellow River basin since 80's of 20 century.

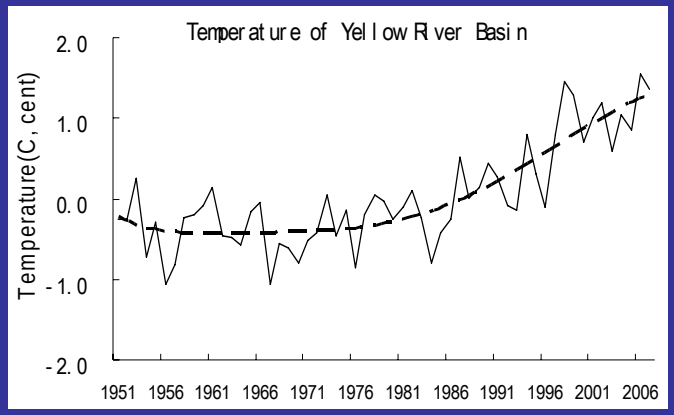


Fig. 1 average temperature change in Yellow River

- **河源区气温升高幅度最大， 0.267℃/10a**
  Sources region, the maximum warming with 0.267℃/10a

- **19世纪80和90年代气温变化幅度最大**
  the maximum extent appeared in 80 and 90's of 20 century, especially 90's with 0.7℃ increment than 1980s.

- 黄河流域多年平均降水量为447mm，降水自东南向西北减少。
  Annual average precipitation in Yellow River basin is about 447mm, and the precipitation decreases gradually from east south to west north of Yellow River basin.

- 20纪90年代降水最少，进入21世纪以来，降水略有增加

  precipitation in 90's of 20 century was the minimum and slightly increased since 21 century.

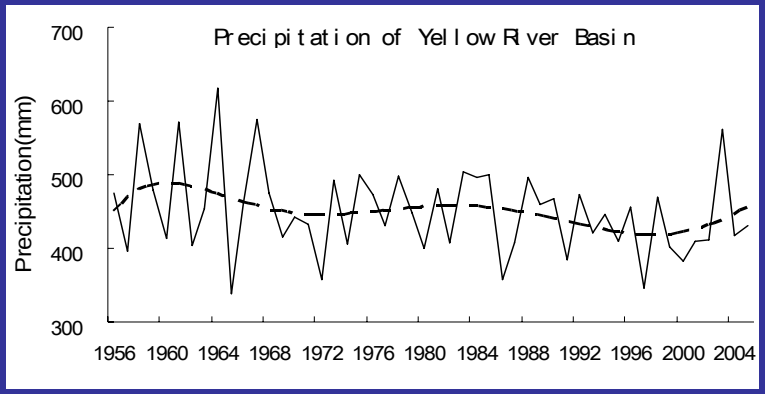


Fig. 2 precipitation change in Yellow River

蒸发 Evaporation

- 蒸发皿蒸发呈下降趋势(春季和夏季下降最为明显)，原因是日照时数及太阳辐射的减少，平均风速和气温日较差的降低也起一定的作用；

  Pan evaporation has been decreasing in recent decades, most obvious descending occurs in spring and summer. the reduction of solar radiation may be the direct reason of pan evaporation descending, moreover, the decreasing of average wind and diurnal temperature range are also important factor.

- 与蒸发皿蒸发相反，黄河流域实际蒸发呈逐年增大的趋势

  原因是灌溉等用水量加大造成的，

  Being contrary to pan evaporation, actual evaporation has increasing trend, the reason is the sharply increasing of irrigation water (main reason)

2. 黄河流域水资源变化特点
Change of water resources in YRB

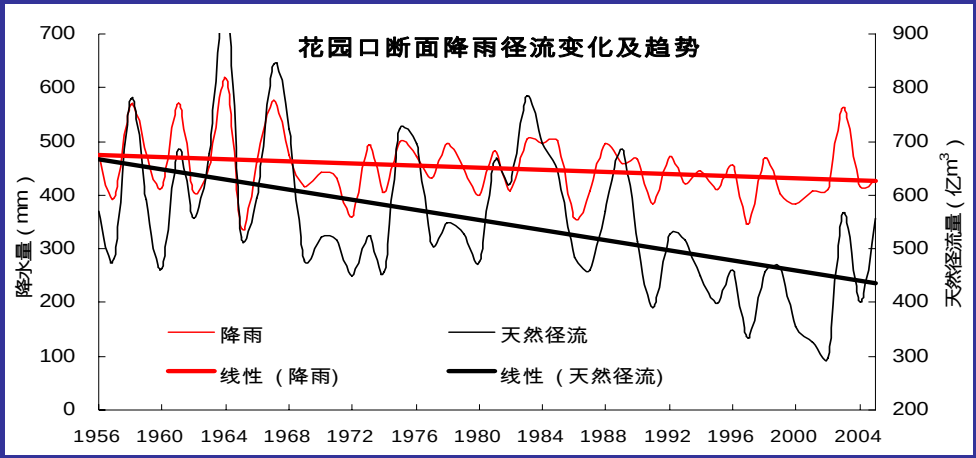
- 气候变化和人类活动加重了黄河流域水资源供需矛盾，黄河水沙关系愈加不协调，增加了河道防洪防凌压力，给流域管理带严峻挑战。

  Water resources shortage are aggravated by climate change and human activities, Relation of water and sediment are becoming more unbalance, which increase the stress of reach flood and ice protection, it is a serious challenge to basin management.

径流 Runoff

- 天然径流量与降水均呈减少的趋势，径流减幅大于降水减幅。

  Both runoff and precipitation are tend to decrease, the range of runoff decreasing is larger than precipitation.



change of precipitation and nature runoff in Yellow River basin

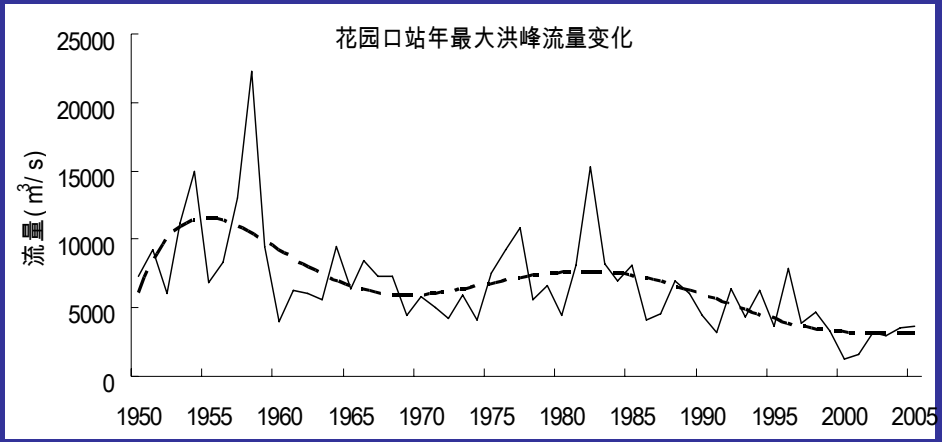
- 黄河源区20世纪90年代天然径流量为176亿m^3，比多年平均（205亿m^3）减少15%。研究认为气候变化是天然径流减少的主要原因.

  Runoff in source YR basin is 17.6 billion m^3 in 1990's, which decreased 15% than annual average value (20.5 billion m^3). Some researcher believes that climate change is the main reason of nature runoff reduction in source YR basin.

暴雨与洪水 Rainstorm and Flood

•20世纪90年代以来，黄河暴雨洪水频次和量级变小，干旱日趋严重。

Frequency and magnitude of rainstorm and flood in YR become smaller since 1990's, while the drought becomes more serious.



the maximum flood peak discharge of Huayuankou station

- 花园口下游漫滩洪水，20世纪50年代9次；1986～2000年的15年期间只有3次。从2002年至今，下游最大洪峰流量只有4200m3/s。

  there were 9 times overbank floods in 50's of 20 century; but only 3 times in 15 years form 1986 to 2000. The maximum of flood peak discharge in lower reach was only 4200 m3/s from 2002 to now.

旱情 Drought events

- 干旱缺水是黄河的主要问题。据观测资料记录，黄河流域从上世纪60年代起就有不同程度的干旱，90年代以来，干旱程度不断加剧，范围逐渐扩大。气候变化导致的来水量减少是流域干旱的重要原因。

  Water shortage is principal problem in Yellow River. Basing on observed record, Yellow River basin has been experiencing continuous drought since 1965, Entering 90's of 20 century, drought situation was aggravated and drought area extended gradually. Water flow reduction caused be climate change is an important reason of basin drought.

Ice Flood 河流冰凌灾害

- 1990年代以来，冬季气温明显偏高，黄河宁蒙河段凌情呈现新特点:
  ① 封河天数减少，封开河日期不稳定，预报难度增大；
  ② “地上悬河”发展，开河期水位持续增高，堤防压力增大。
  Ice flood is very serious than any other rivers because of its variance reach channel. Since 1990’s, ice regime in Ningmeng reach shows new character with the temperature remarkably rising in winter:
  ① frozen days decrease and freeze-up date is difficult to forecast for its unconstant character.
  ② the “aboveground river” situation developed and water level in break-up period increased gradually, consequently the dike stress was strengthened.

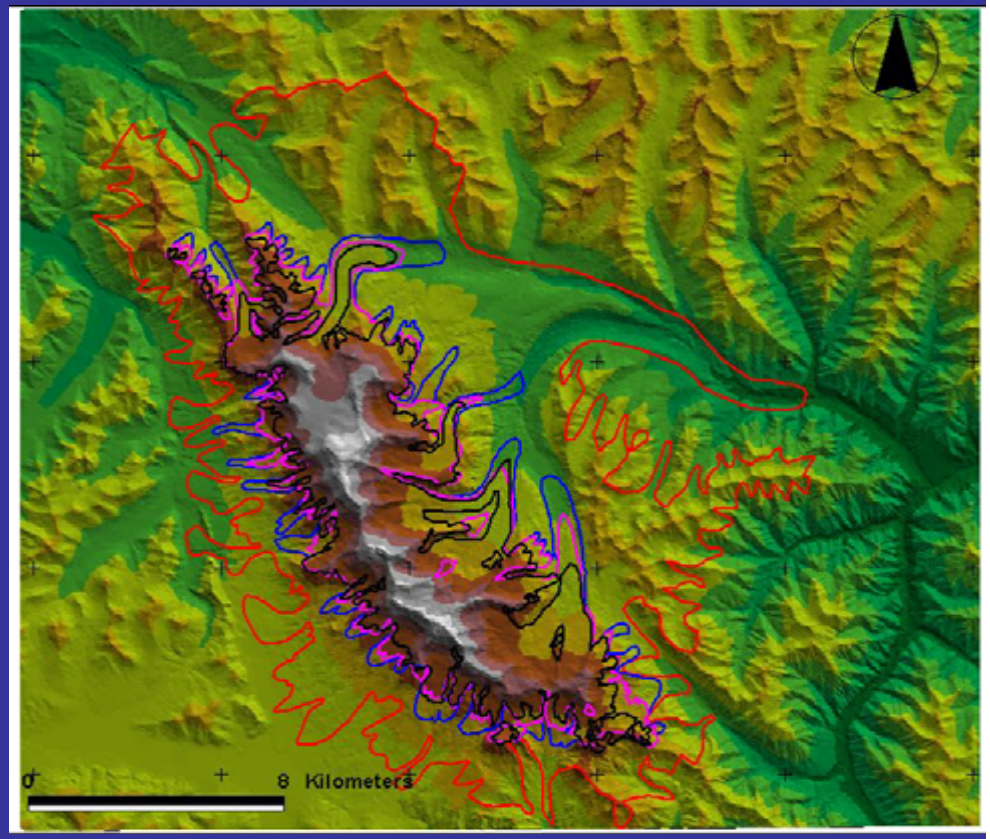
冰川消融：气候变暖的证据
Glacier: evidence of climate warming

- **冰川**

  最近35年（1966~2000）内，气候变暖导致黄河源区阿尼玛卿山冰川总面积减少了17%，高山雪线上升了近30米

- **Glacier**

  In recent 35 years 1966~2000, glacial area in Animaqing mountain reduced 17%, and alpine snowline increased about 30m



冻土 Frozen soil

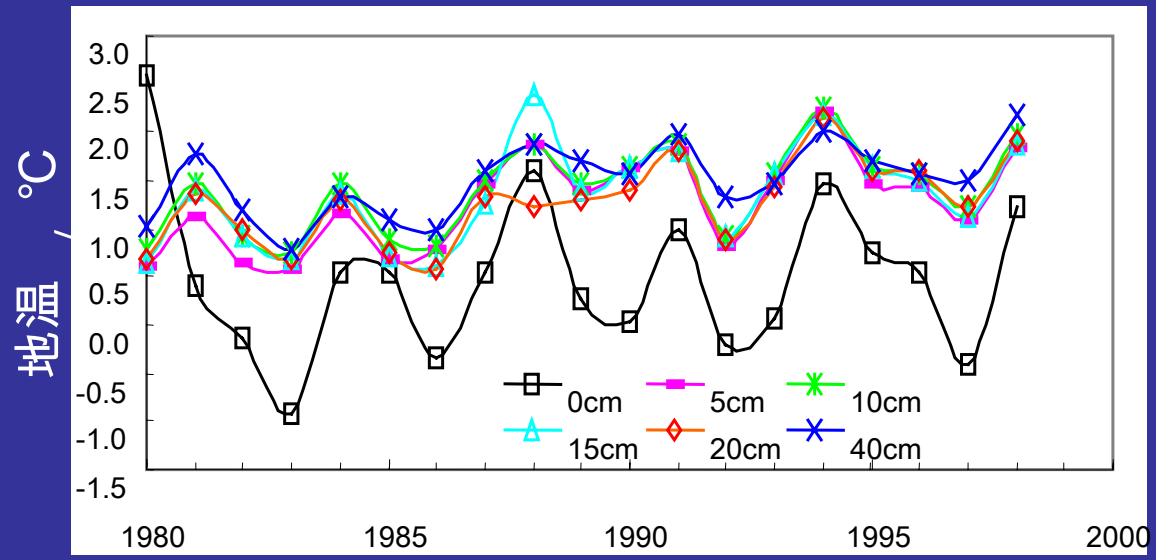
气温升高导致黄河源区冻土融化

- 季节冻土温度：升高 0.3～0.7℃；永久冻土： 0.1～0.4℃

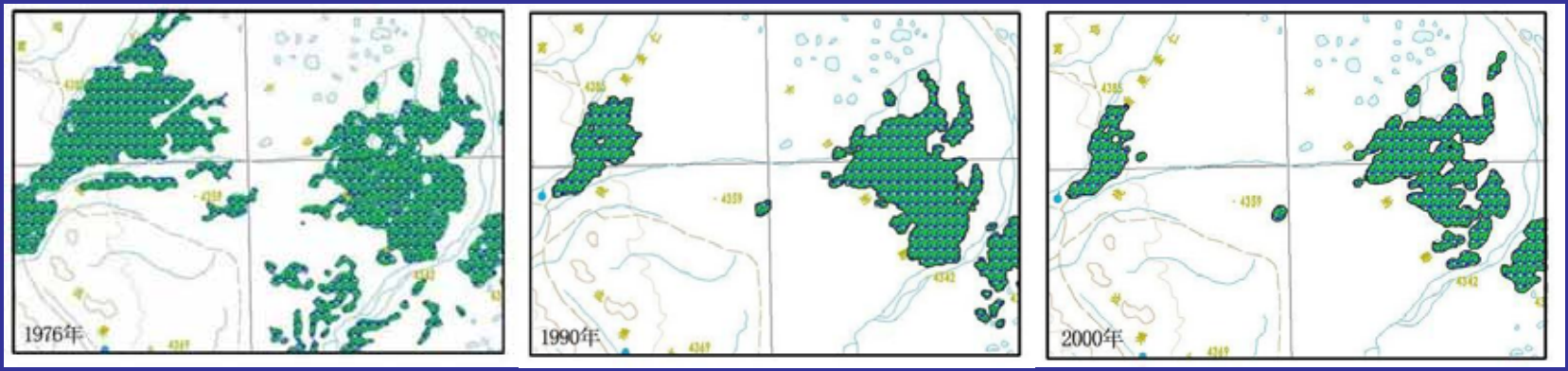
Seasonal soil: 0.3～0.7℃; Permafrost: 0.1～0.4℃

- 季节冻土上边界上升速度： 2～10cm/年；最近几十年永久冻土下界升 高了50～70cm

Seasonal soil upper boundary: 2～10cm/a; Permafrost lower limit increased



湖泊与湿地 Wet land

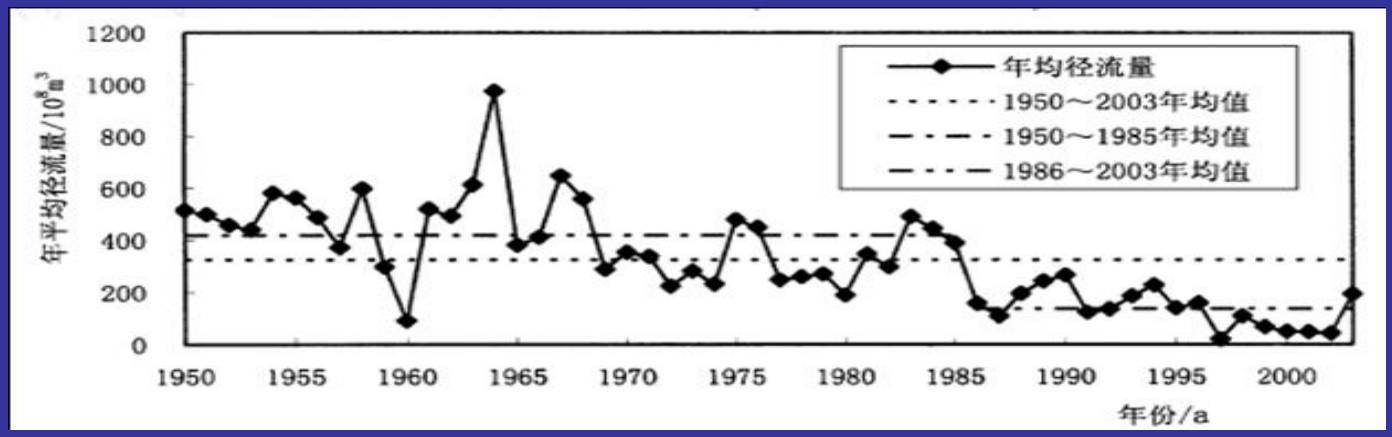


黄河源区多石峡以上区域湖泊沼泽变化
Swamps and lakes change upper Duoshixia of source Yellow River

- 许多湖泊萎缩甚至消失，草场退化，生态环境恶化。黄河源区2000年沼泽湿地及湖泊面积比1976年减少了近3000km2。

  many lakes disappeared and grass land degenerated, consequently these lead to ecological environment deterioration. It's analyzed that total area of wet land and lake in 1976 reduced approximately 3000km2 than 2000 in source of Yellow River.

河口生态 Estuary Ecosystem



Annual average runoff in estuary of Yellow River

- 入海水量减少导致黄河下游河道萎缩严重，二级悬河迅速发展，不仅使堤防“冲决”和“溃决”的可能性增大，还导致下游河道内湿地萎缩，水质恶化，生物多样性受到破坏等。

  Decreasing of fresh water to ocean led to severe channel shrinkage and secondary suspended river expending, which not only increase the possibility of dike breach but also the wet land shrinking, water quality deterioration and biodiversity destruction in lower reach.

气候变化和人类活动使黄河流域水资源发生了明显变化。这种影响是广泛而深刻的，涉及到流域水循环的各个环节；气候变化和人类活动对水资源的影响是交织在一起。20世纪80年代以来，气候变化是否已经对黄河流域水资源产生了趋势性的影响，未来气候变化对黄河流域水资源产生何种影响，是有待进一步研究的重大问题。

Surface water resources of Yellow River have been obviously changed Climate change since recent years by climate change and human activities. There are wide and deep impact on water resources system that are relative to each part of water cycling system. Climate change and human activities are combined to effect on water resources. Since 80’s of 20 century, whether climate change has definitely effected on water resources tendency? What the water resources will be under future climate condition? These are very important questions need to be further research.

4. 气候变化影响研究展望
Prospect of CC effects research

黄河流域气候变化研究正在兴起

Researches on CC effects in YR are spring up

- 2008年4月，“水利部应对气候变化研究中心”在南京成立，标志着中国水利在应对气候变化的科学研究和技术支持领域迈出了实质性的一步，必将推动气候变化对中国流域管理和规划影响研究的进程。

  与此同时，中国-欧盟流域管理项目开始了气候变化对水资源影响研究，项目将会给出在气候和社会经济综合情境下，黄河流域未来水资源的 发展趋势，为黄河水资源管理提供科技支撑 。

  “Research Center for Climate Change, Water Resources Ministry of China” was founded in April, 2008. It is a milestone that promotes progress of CC impact on river basin management

  At the same time, EU-China River basin management programme started the research on climate change impact on river basin management.Under the circumstances of climate and social economy, to show the tendency of the YR future water resources, so as to provide technical support for the YR WR Management.

气候变化适应性对策研究的重点

Key points of adaptive measure researched on climate change

- **开展气候变化与极端气象水文事件研究**
  Pay more attention to extreme events research

  黄河流域灾害类型多，干旱、洪水和冰凌灾害发生频繁，带来的损失很大。目前黄河流域气候与水资源研究主要集中在气候变化对流域径流平均变化的影响上，缺少气候变化对水文极端事件研究。

  Yellow River has many kinds of nature disaster such as drought, flood and ice flood. At present, researches relative to climate change and water resources are only focused on the impact of climate change on average events of hydrology and lack of study of climate change effects on extreme hydrological events.

- **重视气候变化对流域综合管理影响**
  Recognition of impact of CC on river basin management

  为促进流域一体化管理，黄委提出“维持黄河健康生命”的治黄目标。为实现这一目标，应从流域管理实践出发，着重加强气候变化对黄河流域水沙调控体系、水量统一管理和调度、水土保持和生态环境规划、流域社会经济发展等的影响研究。

  In order to promote river basin integrated management, YRCC take “Keep Yellow River Healthy Life” as objective of Yellow River management. So it is necessary to strengthen researches on climate change impact on water and sediment adjustment system, water uniform dispatching, water and soil conservation and ecological environment plan, social-economic development.

- 总之，开展气候变化对黄河流域管理的影响研究，要从黄河流域管理的实际需求出发，科学识别气候变化和人类活动对流域水资源系统的影响，评估未来气候变化情景下黄河流域水资源变化趋势，有针对性地提出流域水资源管理体系应对气候变化的对策，为黄河流域综合规划和“维持黄河健康生命”提供依据。
- **In order to service to Yellow River Master Plan and “Keep Yellow River healthy life”, researches on impact of climate change in Yellow River basin should give scientific identifying of impacts of climate change and human activities on water resources system and evaluating of water resources trend under climate change scenarios in the future, consequently working out the countermeasures of river basin management to climate change.**


Thank you